One perspective on the future of Six-Sigma

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Abstract: Six-Sigma has maintained momentum for over ten years now, longer than many pundits expected. However, the key question remains: how long will Six-Sigma remain front-page news? The answer is that it will remain front-page news as long as it delivers front-page results. A second, and related question is: how might the initiative morph and evolve in order to remain relevant going forward? This paper suggests that several emerging trends will continue, such as migration to financial services and healthcare, standardisation of Design for Six-Sigma (DFSS), and further globalisation. Longer term, a key challenge appears to be integration into normal operations, rather than managing Six-Sigma as a separate initiative. Eventually, Six-Sigma needs to become part of an organisation's overall quality or business improvement system.

Keywords: Six-Sigma; design for Six-Sigma; lean; quality improvement; business improvement; quality management system; financial services; healthcare; globalisation.

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Biographical notes: Roger Hoerl heads the Applied Statistics Lab at GE Global Research. He is a Certified Master Black Belt, and was Quality Leader for the GE Corporate Audit Staff (CAS). Dr. Hoerl has been named a Fellow of the American Statistical Association and the American Society for Quality, and has been elected to the International Statistical Institute. His introductory text *Statistical Thinking: Improving Business Performance*, co-authored with Ron Snee, was described as '...probably the most practical basic statistics textbook that has ever been written within a business context' by the journal *Technometrics*. His latest book, also written with Ron Snee, is *Leading Six-Sigma, a Step-by-Step Guide Based on Experience With GE and Other Six-Sigma Companies*.

1 Introduction

At the time of writing this, Six-Sigma has already been on an incredible run for about ten years, although it is certainly older than that. In addition to producing billions in bottomline impact for companies seriously implementing it, it has gained notoriety from CEOs, academic institutions, hospitals and non-profits, and quite frankly, shows no signs of letting up soon. Several new journals, websites, conferences, and even companies have started solely focusing on Six-Sigma. Based on journal articles, attendance at Six-Sigma

conferences, and the amount of training going on, Six-Sigma still appears to be on the way up. Can it go on like this indefinitely? Probably not, but as we look at what the future holds, it is worth noting that Six-Sigma has a lot of air left in the sails.

Perhaps the most critical question about the future of Six-Sigma is when it will begin to wind down, and perhaps morph into something else. I think that is still 5–10 years off, based on the evidence noted above. I also feel that while Six-Sigma will evolve over time (continuous improvement also applies to Six-Sigma), there are some core strengths of Six-Sigma that will be maintained, so whatever the ‘next big thing’ is, it will look at least vaguely familiar to Six-Sigma. Some of these core strengths are the use of proven statistical tools, an overall improvement framework or roadmap (such as DMAIC), utilisation of a formal infrastructure to supply the needed people, money, and other resources, freeing top talent to work on the initiative, and of course, reliance on senior leadership commitment.

2 Emerging trends

In terms of future directions, there are at least five trends that have already clearly emerged, and a couple more are logical conclusions. The five emerging trends, which should be a surprise to no one are:

- continuing evolution of Six-Sigma, both in terms of tools, and also in terms of deployment strategies
- integration of Lean Manufacturing with Six-Sigma
- growth in new application areas, particularly financial services and healthcare
- further development and standardisation of DFSS
- globalisation of Six-Sigma.

Six-Sigma has evolved significantly since it first emerged at Motorola. For example, DMAIC has replaced MAIC as the standard project approach, and tools have been borrowed from elsewhere and added to toolkit (e.g., mistake-proofing from Lean Manufacturing). This evolution is logical and healthy, and will expand in the future, especially when academia grasps the full significance of Six-Sigma, and begins more active research into it. For some reason, academia is only now beginning to catch on, and appears more focused on providing consulting and training services than to studying and improving the Six-Sigma methodology.

I believe the Six-Sigma toolkit will continue to selectively add tools, especially from other disciplines. For example, the field of operations research provided discrete event simulation, which has proven very useful in design projects. Hopefully these additions will be selective, because an effort to make Six-Sigma all encompassing by adding as many tools as possible would significantly slow down Six-Sigma deployments. Perhaps something should be deleted each time a new tool is added. Virtually all tools are useful for some situations, but they are not equally important for Black Belts and others conducting projects. Having a core set of tools is an advantage of Six-Sigma that brings speed and simplicity. Master Black Belts can perhaps be expected to continuously

increase the number of tools in their toolkit, allowing Black Belts and Green Belts to focus on the critical few.

The integration of Six-Sigma and Lean Manufacturing is actually a subset of the first point, in that it is an evolution of the Six-Sigma methodology. However, it has been such a hot topic in Six-Sigma journals, books, and conferences, that it merits special attention. Both initiatives are valuable, proven improvement methodologies, hence it is logical that people would like to integrate them. Personally, I am concerned that the approaches popular in the current literature are somewhat naïve, because at their core they seem to attempt to add some Six-Sigma projects to a Lean Manufacturing initiative. The two major reasons why I feel this is naïve, are:

- it misses one of the biggest contributions of Six-Sigma: the overall deployment methodology
- it frequently misunderstands what Six-Sigma actually does, and how this relates to the core contributions of Lean.

Relative to point one, even Lean proponents, such as George (2003), acknowledge that Lean does not provide the ‘culture and infrastructure’ required to sustain improvement. The overall deployment methodology of Six-Sigma, with accompanying formal infrastructure, is a key to its success (Snee and Hoerl, 2003). Since Six-Sigma is perhaps the only major improvement initiative that provides such a deployment methodology, it would appear logical to utilise Six-Sigma as the lead initiative, and bring in others as needed.

On point two, some Lean proponents suggest that Six-Sigma is not suitable for improvement of cycle times, or reduction of waste, Work in Progress (WIP), or non-value added work, the core application areas of Lean. Since Six-Sigma is a generic improvement methodology, however, one can just as easily choose waste or cycle time as CTQs (critical to quality metrics), as physical properties of products. This is simply a misunderstanding of what Six-Sigma actually is, and how it works.

To expand on this point, while Six-Sigma provides a formal, disciplined deployment methodology and problem-solving process, I view Lean more as a collection of world-class operating principles. This is not to disparage Lean, which is based on the Toyota Production System, perhaps the most effective and efficient manufacturing system the world has ever known. Rather than disparaging Lean, this is intended to put it into a proper context. Since Lean was essentially defined empirically based on the practices in use at Toyota (Monden, 1983), it provides more principles than specific tools or methods. For example, use of cell-based work systems, single-piece flow, standardisation, and outstanding housekeeping are more principles than tools.

Given that, how are Lean and Six-Sigma likely to be integrated going forward? I envision in the future, organisations will discover that Six-Sigma provides the best overall deployment methodology, and make it the lead initiative. Lean principles can and should be brought into the picture. I have found them to be particularly valuable in two specific areas:

- as a world-class standard to audit against in the Analyse phase of DMAIC projects
- to be formally considered in the conceptual design and detailed design phases of design for Six-Sigma (DFSS) projects.

The Lean principles can add significant value in the Analyse phase when audited against, in that they will highlight areas of potential improvement. In DFSS projects, new process designs should certainly incorporate the Lean principles, hence consideration of them should be a formal part of the process.

Further, it is perfectly logical to borrow tools from other sources, and integrate them into the Six-Sigma toolkit. As noted above, mistake-proofing is a Lean tool that is being integrated into Six-Sigma by many organisations. A few others will likely follow. It is also important to point out that Six-Sigma is not all-encompassing; there are problems for which Six-Sigma is not the best approach. I discuss this in more detail below, but let me stipulate here that as part of an overall improvement system, Six-Sigma is particularly well suited for 'solution unknown' problems, i.e., where we do not know the solution ahead of time, while Lean approaches will generally be more appropriate when the solution is known ahead of time, e.g. when we want to introduce single-piece flow (in this case, single-piece flow is the solution). The ultimate integration of Six-Sigma and Lean will occur as part of an overall organisational improvement system, which will be much bigger than these two initiatives.

Moving on to the third point, Six-Sigma clearly began in manufacturing, and even today is often associated with manufacturing by the media. Obviously, this is a narrow view, since Six-Sigma is a generic improvement methodology that can be applied anywhere. In terms of expanding the horizons of Six-Sigma, the two application areas that seem to be rising to the top of the heap are healthcare and financial services. Upon careful consideration, this makes sense for a couple of important reasons. First of all, in both healthcare and financial services, the stakes are very high. In healthcare, malpractice costs in the US alone are in the billions of dollars. Healthcare continues to grow as a percentage of the gross domestic products in many countries. In addition, many areas of healthcare are feeling a financial pinch from rigorous cost controls – from the government in many countries, and in the US from Medicare, insurance companies, and others ultimately 'paying the bill'. At the same time the internal costs of healthcare providers are continuing to rise. In financial services, even a minor improvement in something like the default rate on mortgages or credit cards is worth millions, perhaps billions of dollars to major players in these fields.

Another potential reason for growth in these two fields is that both healthcare and financial services share important similarities to manufacturing operations, making migration of Six-Sigma to these areas conceptually easier. One example is the fact that there are often many high-volume, short-cycle processes, such as admitting patients in a hospital, or preparing bills in financial services. Trying to optimise patient flow through a radiology (imaging) centre in a hospital can be viewed as a similar problem to optimising product flow in manufacturing. Producing and mailing thousands, perhaps millions, of credit card bills each month is in essence a huge batch production problem. A second example is the fact that in both areas one can usually find an existing data collection system, although data are often collected for legal or accounting purposes, rather than improvement.

Typical projects in financial services include accounts receivable (collecting money), accounts payable (paying money), credit scoring (deciding who to lend money to), and improving the audit process. One project in accounts receivable (Doganaksoy, Hahn and Hoerl, 2000) utilised a designed experiment to identify the most effective process for finding people with outstanding credit card balances, and led to a US \$2.9 million annual savings. Some sample healthcare projects include data and records management,

optimising flow through radiology (as noted above, this has similarities to a factory), and administering of medication, which is a common source of errors. Commonwealth Health Corporation reduced their cost per procedure in radiology from US \$68.13 to \$49.55 through targeted projects in that area. With almost 100,000 procedures performed a year, this amounts to over US \$1.65 million in annual savings (Cherry and Seshadri, 2000).

Projects in these arenas have many similarities to projects in manufacturing, and also some important uniqueness. For example, on the people side, there is usually more resistance (we are different, Six-Sigma does not apply here), there is not typically a continuous improvement culture, and many people have never been trained in statistics or quality improvement before. On the technical side, data are often harder to come by, processes are often not well defined, and the data that are collected are often discrete or highly skewed (i.e., non-normal). Each of these issues presents a challenge, but with a sound deployment and technical approach, each can be overcome.

DFSS is a critically important aspect of any organisation's Six-Sigma initiative, and is the forth trend mentioned above. Unfortunately, there is still no generally accepted DFSS approach or methodology, i.e., no equivalent to the universal DMAIC approach. While many organisations use the DMADV model (Define, Measure, Analyse, Design, Verify), GE has now added another step after Design (Optimise), and other organisations use a different acronym. Even less agreement would be found if we 'looked under the hood' at the actual tools and deliverables within each step for different organisations' DFSS approaches. Personally, I am not sure anybody has found the 'best' approach; further development is needed, and will occur. Unfortunately, this situation has prevented DFSS from being spread and assimilated as rapidly as the DMAIC approach. Too many organisations have had to 'invent' DFSS for themselves, GE being one such company.

Now that there are DFSS books appearing in the market, and public courses being offered by Six-Sigma providers, the process of evaluation and convergence can begin in earnest. As with any other methodology, people will have the opportunity to see what others are doing, evaluate it for themselves, and find out what works in practice. As this information is shared via conferences and publications, DFSS approaches will gradually converge over time to a generally accepted approach. Of course, as with DMAIC, individual companies will add their own unique twists.

The fifth trend is the globalisation of Six-Sigma. While one could argue that Six-Sigma has been a global initiative from the beginning, one could also argue that the vast majority of the effort in Six-Sigma has been in the US, at least until the last few years. While many, perhaps most, of the major manufacturers in the US have some form of a Six-Sigma initiative going by now, this cannot be said of manufacturers in the European Union or Asia, such as the People's Republic of China. Certainly some companies in the European Union and Asia are achieving great results with Six-Sigma, such as Samsung in the Republic of Korea, but this does not appear to be nearly as widespread there as in the US.

This situation will change, and in fact, has already begun to change. Simple competitive pressures will require it. Organisations foregoing Six-Sigma will likely find it hard to compete on either cost or quality, unless they have found a methodology that is just as good. So while much of the Six-Sigma 'ground' in the US has already been 'plowed', there are plenty of fertile fields elsewhere in the world. While I am not in the Six-Sigma consulting business, I suspect the lion's share of the future consulting opportunities in Six-Sigma, especially those in manufacturing, lies in the Europe Union and the Asian continent.

3 Potential longer term trends

While these trends are readily evident to anyone paying close attention, there are some other potential trends that are happening in a more subtle way. One such potential trend is the move to integrate Six-Sigma into normal operations, as opposed to managing it as a separate initiative indefinitely. Eventually, Six-Sigma needs to be integrated into an overall quality management system (call it an 'improvement' system if you do not like the word 'quality'). While everyone I have discussed this with agrees that this should happen, there is little evidence that it has occurred yet on a broad scale. In fact, some view Six-Sigma *as* their quality system. However, it should be clear to experienced quality professionals that Six-Sigma is an improvement methodology, not a holistic quality management system. It does not replace ISO standards, the Baldrige criteria, or customer service hotlines, for example.

In addition, not every improvement project should be done using Six-Sigma. For example, I would argue that installing a new piece of equipment, which should lead to improvement, is not really a Six-Sigma project, because there is no problem to be solved. This type of project should be effectively implemented using sound project management techniques, but we know the solution ahead of time, hence we really do not need Six-Sigma. This leads to the obvious question of which projects should be Six-Sigma projects and which should not be. First of all, Six-Sigma is designed to discover and address root causes of problems. Therefore, it should be applied to 'solution unknown' projects, i.e., those where we do not know what the solution is. Many important improvement projects have a known solution, and are therefore not good Six-Sigma candidates. Examples include upgrading a computer network to a newer release, implementing a new project management process, and installing skylights in a factory to improve natural lighting, and reduce electricity costs.

In addition, Six-Sigma projects should be 'doable' in 3–4 months. Therefore, developing cold fusion, although a solution unknown project, is not a good candidate for Six-Sigma. Similarly, there will be simpler 'just do it' projects that do not require the rigour of Six-Sigma, nor 3–4 months to complete. An example would be improving the housekeeping in a manufacturing unit. This leads to the question of what type of approaches should be used when Six-Sigma is not appropriate. What is needed is an overall business improvement system, of which Six-Sigma is one part. But what should this overall system look like, and exactly how does Six-Sigma fit in? These are the key questions that need to be answered, and which will receive much more attention in the future than they have in the past. In fact, one might argue that for long term, institutionalised benefit, these are the ultimate Six-Sigma questions. Clearly, more research needs to be done on how to best integrate Six-Sigma within an overall, holistic quality or improvement system.

Because of this issue, it is also reasonable to assume that Six-Sigma will begin to broaden in scope, to fill some of these voids. For example, there are many problems for which no solution is known, but which require more than the typical 3–4 months of a Six-Sigma project to solve. Some of these problems can be broken up in smaller projects, with Six-Sigma being used on each. However, what if the overall project is of such complexity that it is not reasonable to solve through several separate projects? Also, what about unsolved problems that require less than 3–4 months to solve? One could speculate

that Six-Sigma will evolve over time to incorporate solutions to such problems, just as the Six-Sigma toolkit has broadened over time.

A potential concern is that if Six-Sigma becomes too broad, it will lose the advantage of being so specific and well defined. One common problem with many total quality management (TQM) implementations in the 1980's was that TQM became so all-encompassing (hence the word 'total') and intangible, that it became virtually impossible to manage or evaluate. One could argue that being narrowly focused on addressing unsolved problems that required 3–4 months to solve, has been a key to success for Six-Sigma. Therefore, I would suggest that integrating Six-Sigma into an overall improvement/quality system should be the priority, versus continuously broadening Six-Sigma. Six-Sigma was not designed to be a holistic quality system, and we should resist the temptation to make it one.

4 Summary

In summary, Six-Sigma continues to build momentum, with no signs of letting up. If it is to remain impactful over time, however, it will need to continue to evolve and adjust to changes in the environment. Several trends are already emerging, including continuous expansion into all aspects of the economy, especially healthcare and financial services, evolution of the toolkit, further development and standardisation of DFSS, and globalisation. While Six-Sigma has come close to saturating the US manufacturing market, there are still huge opportunities in finance, healthcare, and other areas of the US economy. In addition, Six-Sigma does not appear to have yet peaked on a global basis it is still growing in Europe and Asia, in particular. Much of the future growth, especially outside manufacturing, should be in these two continents. At this point in time, there is significant variation from organisation to organisation in how DFSS projects are conducted, relative to the variation in DMAIC projects. This variation in DFSS approaches should gradually decrease over time. The integration of Six-Sigma with other methodologies, such as Lean Manufacturing, will continue, but probably in a more logical manner, with Six-Sigma providing the overall deployment and problem solving structure. Longer term, it will be necessary to integrate Six-Sigma as one component of an overall quality management or improvement system. Six-Sigma is excellent at what it does – driving bottomline improvements in a short amount of time, but it is not a holistic quality or business management system. I expect this last point to be ultimately the most critical Six-Sigma question, and the topic we will be talking about most in Six-Sigma conferences and journals 5–10 years from now.

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